The relationship between surface water chemistry and geology in the North Branch of the Moose River

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Abstract. The chemistry of lakes and streams within the North Branch of the Moose River is strongly correlated with the nature and distribution of geologic materials in the watershed. The dominance of thin glacial till and granitic gneiss bedrock in the region north and east of Big Moose Lake results in a geologically sensitive terrain that is characterized by surface water with low alkalinity and chemical compositions only slightly modified from ambient precipitation. In contrast, extensive deposits of thick glacial till and stratified drift in the lower part of the system (e.g. Moss-Cascade valley) allow for much infiltration of precipitation to the groundwater system where weathering reactions increase alkalinity and significantly alter water chemistry.

The hypothesis that surficial geology controls the chemistry of surface waters in the Adirondacks holds true for 70 percent of the Moose River watershed. Exceptions include the Windfall Pond subcatchment which is predominantly covered by thin till, yet has a high surface water alkalinity due to the presence of carbonate-bearing bedrock. The rapid reaction rates of carbonate minerals allow for complete acid neutralization to occur despite the short residence time of water moving through the system. Another important source of alkalinity in at least one of the subcatchments is sulfate reduction. This process appears to be most important in systems containing extensive peat deposits.

An analysis of only those subcatchments controlled by the thickness of surficial sediments indicates that under current atmospheric loadings watersheds containing less than 3 percent thick surficial sediments will be acidic while those with up to 12 percent will be extremely sensitive to acidification and only those with over 50 percent will have a low sensitivity.

Introduction

The extent of the impact of acid rain on surface water chemistry is determined primarily by the chemical reactions which occur as precipitation moves along the various flow paths through the terrestrial system (Newton and April, 1982). Reactions within the surface water bodies themselves are generally of secondary importance (Driscoll and Newton, 1985).

Precipitation falling on a watershed may travel as; surface runoff, shallow interflow, groundwater flow through unconsolidated surficial materials, or through bedrock fractures. Water which moves as surface runoff and interflow moves rapidly to rivers and lakes and has little time to react with the minerals in the soil; only reactions which occur rapidly...
(i.e. cation exchange) can occur. Water flowing through the groundwater reservoir moves much more slowly and has time to react with the mineral comprising the aquifer skeleton. The residence time is generally long enough for even relatively low solubility minerals such as feldspar to react enough to neutralize incoming acidity. Water moving through fractures in the bedrock generally moves quite rapidly and probably reacts only with those minerals which have high solubilities (i.e. calcite).

In Adirondack surface water bodies the most important alkalinity producing reaction is sulfate reduction (Driscoll and Newton, 1985). Sulfate reduction usually occurs in areas where there is an abundance of organic sediments such as bogs and swamps. It appears to be a dominant process in only a few of the Adironack systems.

The results from the Integrated Lake Watershed Acidification Study (ILWAS) have shown that the thickness of unconsolidated surficial sediments is most important in determining the flow path and thus the impact of acid rain on the three watersheds of that project (April and Newton, 1984). The watershed of Woods Lake, an acid system, is predominantly overlain by thin glacial till with numerous bedrock outcrops while the watershed of Panther Lake (pH 7) is covered by thick till (> 3 m). Both watersheds are underlain by similar bedrock of granite-gneiss composition. The thick till cover in Panther Lake watershed provides a large groundwater reservoir. Only during spring melt is the capacity of this reservoir exceeded, causing significant surface runoff. The infiltration capacity of the soils is high enough so that during most precipitation events the water infiltrates the soils, moves down through the till and is slowly discharged to the lake through groundwater seepage. In the watershed of Woods lake the thin till can only support a small groundwater reservoir. The capacity of this reservoir is exceeded by most precipitation events, therefore, most of the precipitation falling on this watershed moves directly to the lake as surface runoff (Newton and April, 1982).

The chemistry of deep groundwater in Panther Lake watershed reveals the extent to which silicate minerals may react with ground water. Samples collected from observation wells installed at a depth of 20 m within the glacial till had an average pH of 7.87 and an average alkalinity of 1740 μeq/1. This indicates considerable chemical reaction between the minerals in the till (feldspar and hornblende) and the infiltrated rainwater.

To test the applicability of these ILWAS findings to the entire Adirondack region, 22 watersheds have been examined as part of the Regionalized Integrated Lake Watershed Acidification Study (RILWAS). Thirteen of these are subcatchments within the North Branch of the Moose River.

The North Branch of the Moose River is of particular interest because it contains surface water having a broad range of alkalinities (Driscoll et al., 1987). Also, the size of the watershed together with the variability of